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Performance of newly developed hollow fiber module with spacer in integrated anaerobicâ€“aerobic fungi reactor treating textile wastewater

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Abstract

A submerged microfiltration membrane bioreactor implementing the white-rot fungus Coriolus versicolor was developed for effective treatment of textile dye wastewater [1]. In that system membrane fouling was precluded by placing a bundle of hollow fibers within a pre-filtration assembly, so as to avoid direct deposition of sludge onto it, together with its periodic high-pressure back-washing and low-dose chemical back-flushing. However, the extreme vulnerability of the bare membrane used in that study to inter-fibral deposition of sludge leading to merging of fibers indicated necessity of development of an appropriate module so that the proposed system may enjoy more flexibility in terms of precluding fouling. This study reports superior performance, in terms of avoiding fouling, of newly developed hollow fiber module with spacer over that of usual hollow fiber bundles under severe operating conditions induced by high strength industrial wastewater with concomitant biofouling.

Keywords

GeoQUEST

Disciplines

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Performance of newly developed hollow fiber module with spacer in integrated anaerobic-aerobic fungi reactor treating textile wastewater

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Introduction

A submerged microfiltration membrane bioreactor implementing the white-rot fungus *Coriolus versicolor* was developed for effective treatment of textile dye wastewater [1]. In that system membrane fouling was precluded by placing a bundle of hollow fibers within a pre-filtration assembly, so as to avoid direct deposition of sludge onto it, together with its periodic high-pressure back-washing and low-dose chemical back-flushing. However, the extreme vulnerability of the bare membrane used in that study to inter-fibral deposition of sludge leading to merging of fibers indicated necessity of development of an appropriate module so that the proposed system may enjoy more flexibility in terms of precluding fouling.

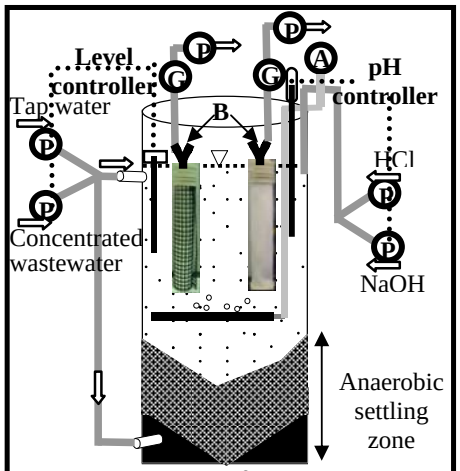

Fig.1 Schematic of laboratory setup (**A**: Air pump, **B**: Backwash, **G**: Vacuum gauge, **P**: Pump)

This study reports superior performance, in terms of avoiding fouling, of newly developed hollow fiber module with spacer over that of usual hollow fiber bundles under severe operating conditions induced by high strength industrial wastewater with concomitant biofouling.

Experimental

The investigations were carried out in an integrated anaerobic-aerobic fungi reactor (**Fig.1**) under a controlled pH of 4.5, using a synthetic wastewater (TOC= 2g/L) containing azo dye (100 mg/L), starch and other nutrients. Adopted reactor-design and split-mode feeding strategy were aimed at minimization of excess sludge-growth and maintenance of less MLSS concentration in contact with the membrane at the upper aerobic zone ('$MLSS_{aerobic}$'). The anticipation that the degree of avoidance of inter-fibral intrusion of sludge may depend on type of spacer, led to preliminary exploration of two types of spacers (**Fig.2a,b**), namely, a rigid spacer with 1 mm thickness and 1 cm^2 openings, and a thin one with 1 mm^2 openings (henceforth referred to as 'rigid' and 'thin' spacer, respectively). A 'hybrid module (**Fig. 2c**)' was also obtained by winding the rigid spacer around the module having soft spacer. During all the investigations, the membranes were operated under average flux of 0.011 m/d with 5 min. on/off mode. The modules were always periodically backwashed (3s/ 10 min. @ 100ml/min.) with permeate, while chemical cleaning, when applied, was performed with NaOCl solution having 0.3 % Cl (100 ml per m^2 membrane surface; every third day).

Results and Discussion

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The modules with rigid and thin spacer along with the unmodified one were directly submerged into the reactor, and corresponding rises in transmembrane pressure (TMP) in the course of operation were monitored (**Fig. 3**). The operation of the unmodified membrane was discontinued following its fatal fouling within one day. The modules with spacer, on the other hand, were very effective in resisting intrusion of sludge. The module having thin spacer exhibited no rise in TMP until day 35, after which a sharp rise up to 45 kpa was observed. In situ chemical cleaning was effective to reinstate the original TMP. However, absence of chemical cleaning from the beginning may have resulted in gradual build up of sludge within the module which could not be completely removed by cleaning applied only following development of very high TMP. Consequently, henceforth, sharp rise in TMP was inevitable, indicating necessity of periodic cleaning from initiation of operation. Conversely, the module with rigid spacer sustained for comparatively shorter period, and more importantly, chemical cleaning could not recover its original state. This may be attributed to its very compact packing, which restricted wash-out of foulants through its bottom end. Accordingly its use was ceased. This initial part of the study divulged the superiority of the modules having spacer over the unmodified one.

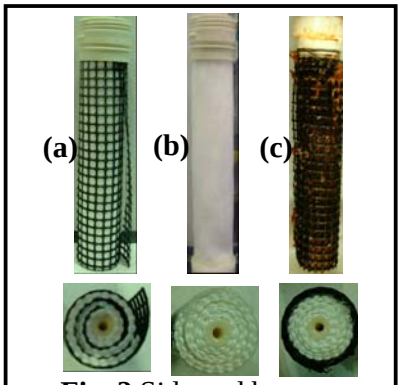


Fig. 2 Side and bottom views of modified modules
(a) Rigid spacer, (b) Thin spacer, (c) Rigid mesh wound around 'module b'

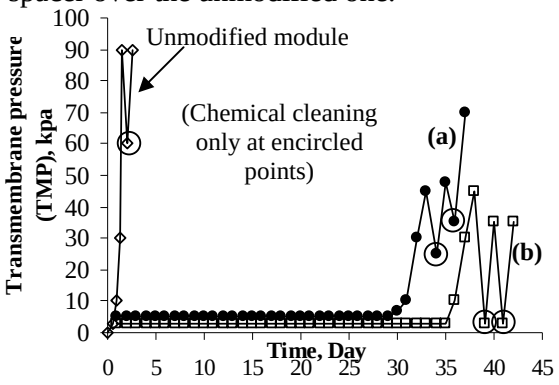
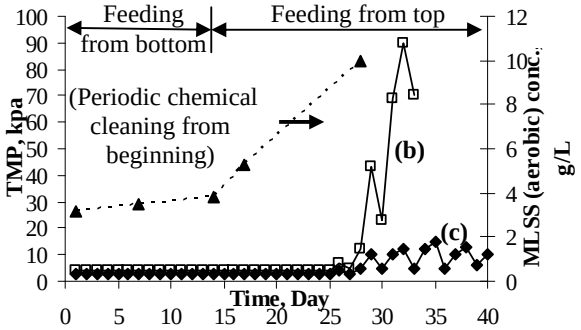


Fig.3 TMP variation during continuous operation under $MLSS_{aerobic}$ = 5 g/L



Numbers (a,b,c) correspond to those in Fig. 2

Fig.4 TMP variation during continuous operation under increasing $MLSS_{aerobic}$

The 'hybrid module' was introduced during the subsequent investigation which aimed at performance-assessment of the modules during continuous operation under progressively increasing $MLSS_{aerobic}$, with low-dose periodic chemical cleaning applied from the beginning. The modules exhibited comparable performances in lower $MLSS_{aerobic}$ range. However, the hybrid module appeared to be more resilient against sludge intrusion in higher $MLSS_{aerobic}$ range, in which the thin spacer module, despite in-situ chemical cleaning, demonstrated frequent very high TMP build-up (**Fig. 4**). This comparative advantage of the hybrid module may have rooted from its optimum compactness due to presence of rigid mesh around it, which restricted intrusion of sludge, but was also flexible enough to allow wash-out of foulants.

Conclusions

The developed module shows great potential for industrial applications.

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